Specification

1. Title of the Invention:

Method for displaying data on computer system

2. Detailed Description of the Invention:

[Field of the invention]

The present invention relates to display of data stored in a database, more particularly to a data displaying method for displaying changes of data with respect to a plurality of variables in case changes of the data stored in the database depend on a plurality of the variables. The present invention also relates to a computer system for executing the method and a recording medium for storing a computer-readable program for executing the data displaying method.

[Background art]

There have been proposed many data displaying methods so far. Each of those methods displays data on a display screen by selecting it from among mass data stored in a database and plotting it with respect to target variables. For example, there is a well-known data displaying method. According to the method, in case data stored in a database is represented by a relationship of $f=F(x, y)$, the x value is fixed to such a certain value as x_0 and the $f=F(x_0, y)$ value is plotted with respect to y, thereby the data given by a plurality of variables as described above is displayed two-dimensionally. This data displaying method can display the f value given by a plurality of variables two-dimensionally, but it has been confronted with a problem that it is impossible to know how the f value is to be changed in case x takes a value other than x_0.

There is also proposed a data displaying method. According to the conventional method, the user or the system specifies x_0 according to a certain reference so as to be displayed in a window that displays $f=f(x_0, y)$ two-dimensionally. The window is displayed separately from another window that displays $f=F(x, y)$ three-dimensionally. This conventional method arises a problem that the user must look away from the main graph in case he/she displays data on another screen, so that the displaying method is not effective so much.

There is still another proposed data displaying method. According to the method, a specific set of variables is extracted from data stored in a database so as to be plotted in three dimensions in a window once. Then, other variables are defined and a cross section of the three-dimensional plot taken at a predetermined value is displayed in another window. The method, however, is not so effective, since it requires the user to use a mass of such calculating resources as a calculation time, a storage capacity, a processor (CPU), etc. Because the method also creates a macro additionally so as to graph data in a spread-sheet program, etc., the procedures are complicated and this makes it difficult to display changes of the f value simultaneously according to the changes of a specific variable while data is plotted with respect to the main necessary parameters.

[Problems to be solved by the invention]

Under such circumstances, it is an object of the present invention to provide a data displaying method that can solve the above conventional problems and make it easier to visualize data to be changed in dependence on a plurality of variables accurately, simply, and effectively. It is another object of the present invention to provide a computer system that carries out the data displaying method and a computer-readable recording medium that stores a program for carrying out the data displaying method.

[Summary of the invention]

The above objects are thus achieved by the data displaying method, the computer system, and the computer-readable recording medium of the present invention.

Concretely, the data displaying method of the present invention is carried out by a computer system that includes a computer with a database; a display device; and a pointer for entering a position on the screen of the display device. The data displaying method comprises a step of displaying a main graph by reading data from the database and plotting the data on the screen of the display device with respect to a first variable; a step of deciding whether or not an input from the pointer is a request for plotting data related to a second variable; a step of deciding coordinate data of a position of the main graph displayed on the screen of the display device; and a step of searching the coordinate data from the database. It is therefore possible to identify object data stored in the database accurately from the plotted main graph when it is displayed. Furthermore, in case an input from the pointer is a request for plotting data related to the second variable, the present invention enables the data displaying method to include a step of reading the coordinate data of the position from the database; a step of displaying a second window at a predetermined position on the screen of the display device that displays the main graph and a step of plotting the coordinate data of the position in the second window with respect to the second variable. This is why it is possible to sub-plot data including a data point identified accurately on the main graph according to a user request. The data displaying method can further include a step of displaying the second window while plotting of the data related to the second variable is requested from the pointer. Consequently, the data displaying method can stop the sub-plotting of data quickly in case the user does not need it any longer. The data displaying method of the present invention also enables the step of searching the coordinate data of a position in the database further include a

step of calculating the coordinate value of the position so as to compare the value with the data value stored in the database. It is thus possible to identify any data stored in the database accurately from the coordinate data of the position on the main graph.

Furthermore, the computer system of the present invention includes computer means with a database; display means; and pointer means for entering a position on the screen of the display means. And, the computer system further includes means for displaying a main graph by reading the data from the database and plotting the data on the screen of the display means with respect to the first variable; means for deciding whether or not an input from the pointer means is a request for plotting data related to the second variable; means for deciding coordinate data of a position of the main graph displayed on the screen of the display means; means for searching the coordinate data of the position from the database; means for reading the coordinate data from the database; means for displaying the second window at a predetermined position on the main graph; and means for plotting the coordinate data of the position in the second window with respect to the second variable. This computer system can also include means for displaying the second window while plotting of the data related to the second variable is requested from the pointer means. Furthermore, the computer system of the present invention enables the means for searching the coordinate data of a position in the database to calculate a coordinate value of a position so as to compare the calculated value with the corresponding data value stored in the database.

Furthermore, the computer-readable recording medium of the present invention stores a program for carrying out the above data displaying method in the above computer system that includes computer means with a database; display means, and pointer means for entering a position on the screen of the display means. The computer program stored on the recording

medium includes a step of displaying a main graph by reading the data from the database and plotting the data on the screen of the display means with respect to the first variable; a step of deciding whether or not an input from the pointer means is a request for plotting the data related to the second variable; a step of deciding coordinate data of a position of the main graph on the screen of the display means; and a step of searching the coordinate data of the position from the database. In case the input from the pointer means is a request for plotting data related to the second variable, the computer program stored on the recording medium of the present invention can further include a step of reading the coordinate data of a position from the database; a step of displaying the second window at a predetermined position on the main graph; and a step of plotting the coordinate data of a position in the second window with respect to the second variable. The computer program stored on the recording medium of the present invention can further include a step of displaying the second window while plotting of the data related to the second variable is requested by the pointer means. The computer program stored on the recording medium of the present invention also enables the step of searching the coordinate data of a position from the database to include a step of calculating a coordinate value of the position so as to compare the calculated value with the data value stored in the database.

[Preferred embodiment]

Hereunder, the preferred embodiments of the present invention will be described with reference to the accompanying drawings. The present invention is not limited only to those embodiments to be described below, of course; it may be modified freely without departing from the spirit of the invention.

Figure 1 shows an embodiment of a computer system for executing the data displaying method of the present invention. The computer system 1 is configured by computer means 2, a display device 3 connected to the computer means 2 and used to display

various data items, and pointer means 4 for issuing a command for reading coordinate data as needed from the main graph displayed on the screen of the display device 3, as well as issuing other various commands. While the pointer means 4 is a mouse in Figure 1, it may be a stylus pen. Especially, the present invention also enables the pointer means to be configured by, for example, a cross line formed on the screen of the display device 3 and moved according to a key operation on a keyboard without using such the mouse/stylus pen. Any of those pointer means 4 can be selected appropriately to the operation environment of the computer system according to the present invention.

The computer means 2 of the computer system 1 shown in Figure 1 may be a personal computer or work station, which employs such a CPU as PENTIUM (trademark of Intel Corporation) or a CPU compatible with that and operate such an operating system as WINDOWS (trademark of Microsoft Corporation), WINDOWS NT (trademark of Microsoft Corporation), OS/2 (trademark of IBM Corporation), AIX (trademark of IBM Corporation), UNIX LINUX, etc. Both of CPU and operating system are not limited only to those, of course.

While the computer system 1 in the embodiment of the present invention shown in Figure 1 is a stand-alone one, it may be connected to another computer system as needed via a network. Such a network may be any one that could send/receive information in a remote mode through the communications, for example, the Internet, optical communications, LAN/WAN, etc. that use a proper communication protocol respectively. The communication protocol used for such the communications may also be the TCP/IP protocol. The communication protocol is not limited only to those, of course.

The computer means 2 included in the computer system 1 of the present invention as shown in Figure 1 includes storage means (not illustrated). This storage means stores a database (DB) that stores data used for the data displaying method of the

present invention.

Figure 2 shows a structure of the data stored in the database DB shown in Figure 1. In the data structure shown in Figure 2, it is assumed that data values of f_i depend on two variables, for example, variables x and y. According to the present invention, however, the number of variables, the number of f_i values, and the characteristics of those variables are not limited specially. For example, it is also possible to use such a discrete value as a "serial No." for the variable x. And, it is also possible to use such a discrete or continuous value as a "frequency" for the variable y.

The data stored in the database DB shown in Figure 2 is formed as a set of instances 5a, 5b, 5c,... of a data class in which a series of data values f_i with respect to x values are stored so as to correspond to changes of y in case the value in the variable x is changed x_0, x_1, x_2, x_3, ... in a discrete manner like. Figure 3 shows a data structure of a data class in detail when the instance 5a of the data class in the database DB shown in Figure 2 is taken as an example.

As shown in Figure 3, in the data class 5a stored in the database DB used by the present invention, f_i, for example a measured data value, which corresponds to each discrete value of the variable Y, is stored in each field. And, in the instance 5a of the data class shown in Figure 3, each data value f_i corresponding to a predetermined y value forms a record.

Figure 4 shows an example of the main graph displayed according to the present invention. According to the present invention, the main graph means each data value f_i plotted with respect to a variable, which is targeted by the user of the computer system 1 at that time. The main graph is not decided uniquely, but it can be selected by the user as needed according to the type of the variable, etc. For the main graph in the embodiment of the present invention shown in Figure 4, the

horizontal axis plots the variable Y and the vertical axis plots, for example, the f_7 value corresponding to the predetermined x_j shown in Figure 3 (j= a positive integer including 0). In Figure 4, data is plotted in correspondence to the f_7 value. For example, a color is changed to another on the screen of the display device 3 in case the variable x_j is changed x_0, x_1, x_2, x_3, ... in a discrete manner like. The main graph shown in Figure 4 makes it possible to check the change of each data value f_7 to be caused by the change of the variable Y accurately enough. In case it is required to make a decision further in detail with use of data, it is required sometimes to know how each data value f_7 is changed at a predetermined Y value when the variable X is changed.

It is a conventional way that the horizontal axis takes a variable X so as to create and display another window in the above case. The above conventional method, however, cannot answer quickly and effectively to a user's question that how the variable X is to be changed at a specific data point existing, for example, on the main graph. And, the user must turn his/her eyes away from the screen of the main graph when executing such operations as displaying another window and/or identifying a variable to the computer system 1. Those troublesome operations will make the user feel that the operation efficiency is very low. This is why the user comes to demand a more efficient method, thereby he/she can come to display, for example, changes of the data value f_1 with respect to another variable at a specific data point displayed on the main graph on the screen of the display 3 without turning his/her eyes away from the main graph.

Figure 5 shows how data is displayed in the embodiment of the present invention. In Figure 5, it is premised that the vertical axis plots the data value f_7 and the horizontal axis plots the first variable Y. In the embodiment of the present invention shown in Figure 5, the second window 6 is overlaid on the main graph described above and data is sub-plotted in the second window so as to denote how the data value f_7 is changed

with respect to the second variable. The plotted data displayed in this second window 6 is assumed to be the data value f_7 in the variable Y denoted by an arrow plotted with respect to the second variable X in Figure 5. A position denoted by an arrow here can be specified with the pointer means 4 for any value in the variable Y marked by the user. The second window 6 displayed according to the present invention can be used as, for example, a pop-up window on the main graph and disappeared when it is not needed.

In the embodiment of the present invention, this second window 6 can be kept displayed until the display request is terminated so that the window 6, when a mouse is used as the pointer means 4, is displayed by clicking the left button of the mouse and kept displayed until the right button of the mouse is clicked again.

Furthermore, in another embodiment of the present invention, it is also possible to continue the display of the second window 6 while the mouse click is continued. When the mouse click is ended, the display request is regarded to be ended, thus the display of the second window 6 is terminated. The sub-plotted data displayed in the second window 6 according to the present invention as described above is configured so as to plot a specific f_i value corresponding to the main graph displayed at that time with respect to the second variable.

Figure 6 shows the main graph in another embodiment of the present invention, in which the display data is changed from the data value f_7 to f_2 stored in the data class 5a shown in Figure 3 respectively in the embodiment of the present invention shown in Figure 5. Such a main graph change, when a mouse is used as the pointer means 4, is done by clicking the left button of the mouse on the main graph when the f_i data is not plotted thereon. And, each time the left button of the mouse is clicked, the display field can be changed sequentially to f_2, f_3, f_4, ... at the f_i data value shown in Figure 3. In such a case, the sub-plotted data in the second window can also

be changed sequentially to f_2, f_3, f_4, ... in accordance with the change.

Figure 7 is a flowchart for describing the data displaying method of the present invention. The data displaying method of the present invention begins a processing in step 701 and data is read from, for example, the f_1 data field with respect to the first variable Y at a predetermined second variable X value so as to plot a graph by displaying the variable Y on the horizontal axis and the f_1 data on the vertical axis in step 702. In case this processing is done repetitively with respect to a different second variable X, the main graph is plotted as shown in Figure 4.

The main graph plotted as described above is then used to decide whether to sub-plot data in the second window in step 703 according to the data displaying method of the present invention. This decision, for example, is done according to whether or not the left button of the mouse (pointer means 4) is clicked in the embodiment of the present invention shown in Figure 7. According to the present invention, data is sub-plotted in the displayed second window by moving the pointer means 4 to a desired point on the main graph and clicking the left button of the mouse (pointer means 4) there.

According to the data displaying method of the present invention, coordinate data specified by the pointer means 4 in step 704 is decided on the screen of the display 3. It is, therefore, possible to employ any other known methods as such the method in case the method standardizes a point on the screen of the display device 3, for example, on the main graph within a displayed data range, thereby calculating coordinate data specified by the pointer means 4.

Then, a record and a field in which object data is stored is searched from the database DB. The object data is the closest one of the data stored in the database DB, which corresponds to the data value calculated from the coordinate data in step 705

as described above. When searching such the data closest to the data value, various references can be used. For example, it is possible to use an absolute difference from the first variable Y among the calculated data values. It is also possible to use a two-dimensional distance that uses the calculated data values and f_i and Y data stored in the database DB as references for searching such the data closest to the above data value. Furthermore, according to the present invention, it is possible to use any reference value that can denote a difference between calculated data and data stored in the database DB. The data calculated from this coordinate data is stored in such a storage means as a memory once, then it is sub-plotted later as to be described with reference to Figures 9 and 11.

Furthermore, according to the another embodiment of the data displaying method of the present invention, in case the above-described closest data is not within, for example, a predetermined threshold, it is possible to change the data value f_i as shown in Figure 6 on the screen of the display device 3 instead of displaying the second window by clicking the left button of the mouse.

In addition to the embodiment shown in Figure 7, the step of calculating data related to the above coordinate data of a position can also be included in a sub-routine for sub-plotting data as to be described later with reference to Figure 9. The step can be included in any other step as long as the effect of the present invention is assured.

As described above, searching the data closest to the data value calculated from coordinate data of a position on the screen of the display device 3 as described above makes it possible to decide both of a predetermined field and a predetermined record in a data class in which data is to be sub-plotted by the user is stored.

Figure 8 shows the data stored and searched in the database DB

as described above and a detailed structure of the database DB employed for the present invention. In the database DB employed for the present invention shown in Figure 8 is defined CMomentData, which is a data class that stores a data value f_i in relation to the first variable Y and are stored a plurality of instances X[0], X[1], X[2],... in the class configured in correspondence to the second variable X. In the database DB is also stored CMomentDoc, which is a data class that puts those data items together therein. In Figure 8, a data value corresponding to both field and record in the database DB, which is the closest to the data calculated from the coordinate data of a position described with reference to Figure 7 is denoted by F. Concretely, as shown in Figure 8, a point marked by the user on the screen of the display device 3 becomes data F(Y=0.55, f_1=26) in the embodiment of the present invention.

In the CMomentData class that defines a relation between Y and f_i corresponding to an X value is held those data items as, for example, iY[] and if$_1$[] array member variables. In order to reference to the Y and f_i values with respect to a specific position of the Y from this CMomentData class, an index of the Y position is used. For example, in case setIndex() that specifies an index of a data value as a member function is defined, the first record for the first variable Y is specified at setIndex(1). After this, for example, the first record Y value 0.03 can be referenced at a member function of Y() or the f_1 value 0 can be referenced at a member function of f_1(). According to the present invention, the data reference by an index described above is just an example. The present invention makes it possible to use any other methods that can reference to member variables directly and more simply.

Furthermore, according to the present invention, a change of the second variable X is represented by a difference between instances of the CMomentData class. Concretely, the CMomentDoc class that denotes a database entirely includes CMomentData class instances corresponding to the variable X values x_0, x_1, ... Therefore, the CMomentData class instance corresponding

to a specific X value is referenced by the index that denotes the instance number. For example, in case "n" is specified for an index of setIndex(n) (n: an integer over 1) with use of the data structure shown in Figure 8, the n-th CMomentData class instance X[n] for the second variable is referenced. And, specific Y and f_i values can be referenced for this instance with use of the above method. Data to be sub-plotted can thus be obtained.

Figure 9 is an example of a flowchart for describing how to sub-plot data according to the data displaying method of the present invention. According to the data displaying method of the present invention, in case a mouse button is clicked in step 703 shown in Figure 7, the data to be sub-plotted is searched and identified as described above. This processing can be executed in any step as described above. Then, control goes to step 901 so as to set "showXDependency", which is a flag for sub-plotting data. After this, control goes to step 902 so as to call the function "onDraw" for displaying a screen. The main graph is thus plotted on the screen in step 903.

Then, control goes to step 904 so as to decide whether or not the flag "showXDependency" is set. In case the flag is set, control goes to step 905 so as to call the function "drawSubPlot" and sub-plot data with reference to the data to be sub-plotted as described above. Control then goes to step 906 so as to decide whether to continue the display of the second window. In the embodiment of the data displaying method of the present invention shown in Figure 9, this decision is done by checking whether or not the right button of the pointer means 4 (ex., a mouse) is clicked. Of course, the method of the present invention enables any other means to be used for this decision in case the method meets the requirement.

In the embodiment of the data displaying method of the present invention shown in Figure 9, in case the right button of the pointer means 4 (ex., a mouse) is clicked (decision = NO) in

step 906, control goes to step 907 so as to reset the flag "showXDependency". Control then jumps to 902 so as to display the main graph. And, in step 904, it is decided again whether or not the flag "showXDependency" is set. Because the flag "showXDependency" is still reset in step 907, it is decided that no data is sub-plotted in step 904. Then, the data display method of the present invention is exited in step 908.

In case the right button of the mouse is not clicked (decision = YES) in step 906, it means that the user requests displaying sub-plotted data. Therefore, the flag "showXDependency" is not reset and the data is sub-plotted on the main graph and in the second window again. As described above, the data displaying method of the present invention continues the display until the user stops the display in the second window in step 907.

Figure 10 shows a pseudo code "CMomentView" for plotting the main graph according to the data display method of the present invention. In the pseudo code shown in Figure 10 are used variables XData, xIndex, selection and showXDependency. The XData, xIndex and selection are used to point out a specific record in the DB. The showXDependency is used to decide whether to sub-plot data. In addition, another variable subPlotPosition is used so as to specify a position for displaying the second window and sub-plot data.

In the case of the processing of the pseudo code shown in Figure 10, "getScreenSize()" is used to specify a size of the display screen. Then, "setMainGraphAttribute()" is used to set conditions required to display the main graph, such as setting of a horizontal axis range, a vertical axis range, a grid plotting color, a line type, a font, etc. Furthermore, "setGraphPositionAndSize()" is used to calculate a place and a size of the main graph. After this, "getData(xData, xIndex)" is used to read a data value f_i from a predetermined CMomentData with reference to an index of xIndex. The data value f_i is included in the CMomentDoc data class. Then, the data value f_i selected from the data values f_1, f_2, f_3,... of the read xData

and specified by a variable "selection" that identifies a data value for displaying the main graph is displayed at "drawMainGraph(xData, xIndex, selection)", thereby the main graph appears on the screen of the display device 3.

Figure 11 shows the pseudo code of the "drawSubPlot" to be executed by the data displaying method of the present invention. At first, this subroutine "drawSubPlot()" defines the variable "subPlotYIndex" to which an index that denotes the first variable for displaying sub-plotted data is entered and the "subPlot[]" to which the value of the data to be sub-plotted is entered.

In 6.1, the first variable for sub-plotting is selected. In this processing, at first it is decided whether to sub-plot data in "if(showXDependency)". In case the flag "showXDependency" is set, the data is sub-plotted in the processings in and after 6.1.1. As shown in 6.1.1, at first, an index that denotes the first variable Y having the first variable value closest to a position where the mouse button is clicked as described above is read into "subPlotYIndex" with use of the function "setSubPlotY()". Then, the instance X[xIndex] of the CMomentData class specified by xIndex is referenced in 6.1.2. Then, the data field specified by "selection" is referenced so as to enter the data to be sub-plotted to the Y position specified by subPlotYIndex is displayed with respect to the same instance. For example, to reference to the data in the first variable Y shown in 6.1.1 at selection $=f_1$, the data is entered as follows.

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"xData->setIndex (xIndex);
xData->X()->setIndex(subPlotYIndex);
subplot[xIndex]=xData->X()->f 1();"
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Then, the processing is repeated only for xIndex as many times as the number of the second variable discrete values, thereby reading the data to be sub-plotted. As shown in Figure 11, according to the present invention, it is possible to search a

data value from the coordinate data, identify the data to be sub-plotted, and read the data by the sub-plotting sub-routine.

After this, in the case of the pseudo code shown in Figure 11, both size and position of the sub-plotting is specified for "setSubPlotSize" in 6.1.3. Then, both maximum and minimum values of the vertical axis in the sub-plotting are set in 6.1.4. In order to specify and set those items, for example, it is also possible to use the 1/4 height in the vertical direction of the main graph and the size in the horizontal direction corresponding to the number of variables for plotting as needed. Of course, the present invention makes it possible to use any other references for the above processings. And, the position for displaying the second window when in sub-plotting may be decided at a position where the button of the pointer means 4 (ex., a mouse) is clicked so as to request, for example, sub-plotting. Of course, the present invention makes it possible to use any other references so as to specify the position for displaying the second window.

Then, both maximum and minimum values of the vertical axis in the sub-plotting can be set for "setSubPlotAttribute()" in 6.1.4 equally to, for example, both of decided maximum and minimum values. After this, the sub-plotted data is displayed at "drawSubPlot()" in the pseudo code shown in Figure 11.

As described above, the data displaying method of the present invention makes it possible to display the second window so as to be overlaid on the main graph effectively. And, the present invention can apply to such event driving type operating systems as Windows, Windows NT, OS/2, AIX Windows, etc. for drawing on a screen from a main loop event message. In addition, the data displaying method of the present invention can be installed as a module of an existing data drawing software program or an additional software program in the subject computer system. The present invention enables the method to apply to any computer systems that use software programs for processing program messages and drawing pictures

on the screen. The data displaying method of the present invention can also apply to processings for handling such a discrete value as measured data, as well as continuous data represented by a predetermined function. The display screen obtained by the data displaying method of the present invention can be printed out by such proper output means as a laser printer, an ink jet printer, or the like.

Furthermore, the data displaying method of the present invention can be described with any object-oriented programming languages, such as the C++ language and the source code for executing this data displaying method can be stored on a computer-readable recording medium such as a floppy disk, a hard disk, a CD-ROM, a DVD, and a magnetic tape. And, the source code for executing the data displaying method of the present invention can also be stored on a medium to be transmitted.

While the present invention has been described in some embodiments shown in the accompanying drawings, the present invention is not limited only to those embodiments; for example, the hardware and software configurations, as well as the execution order in the program may be varied freely as long as the effects of the present invention are ensured.

3. Brief Description of the Drawings:

Figure 1 is a schematic configuration of a computer system in an embodiment of the present invention;

Figure 2 is a schematic structure of a database in the embodiment of the present invention;

Figure 3 is a data class stored in the database in the embodiment of the present invention;

Figure 4 is a main graph displayed on the screen of a display

device according to the data displaying method of the present invention;

Figure 5 is a graph displayed in the second window overlaid on the main graph shown in Figure 4;

Figure 6 is the main graph in another embodiment of the present invention;

Figure 7 is a flowchart for describing the data displaying method of the present invention;

Figure 8 shows data identified from both field and record, as well as a detailed structure of the database DB that stores data according to the present invention;

Figure 9 is a flowchart continued from the flowchart of the data displaying method of the present invention shown in Figure 7;

Figure 10 is the pseudo code of a program for displaying the main graph according to the data displaying method of the present invention; and

Figure 11 is the pseudo code of the program "drawSubPlot" used in the present invention.

[Description of symbols]

1 ... Computer System
2 ... Computer Means
3 ... Display Device
4 ... Pointer Means
5 ... Data Class
6 ... Second Window
DB ... Database